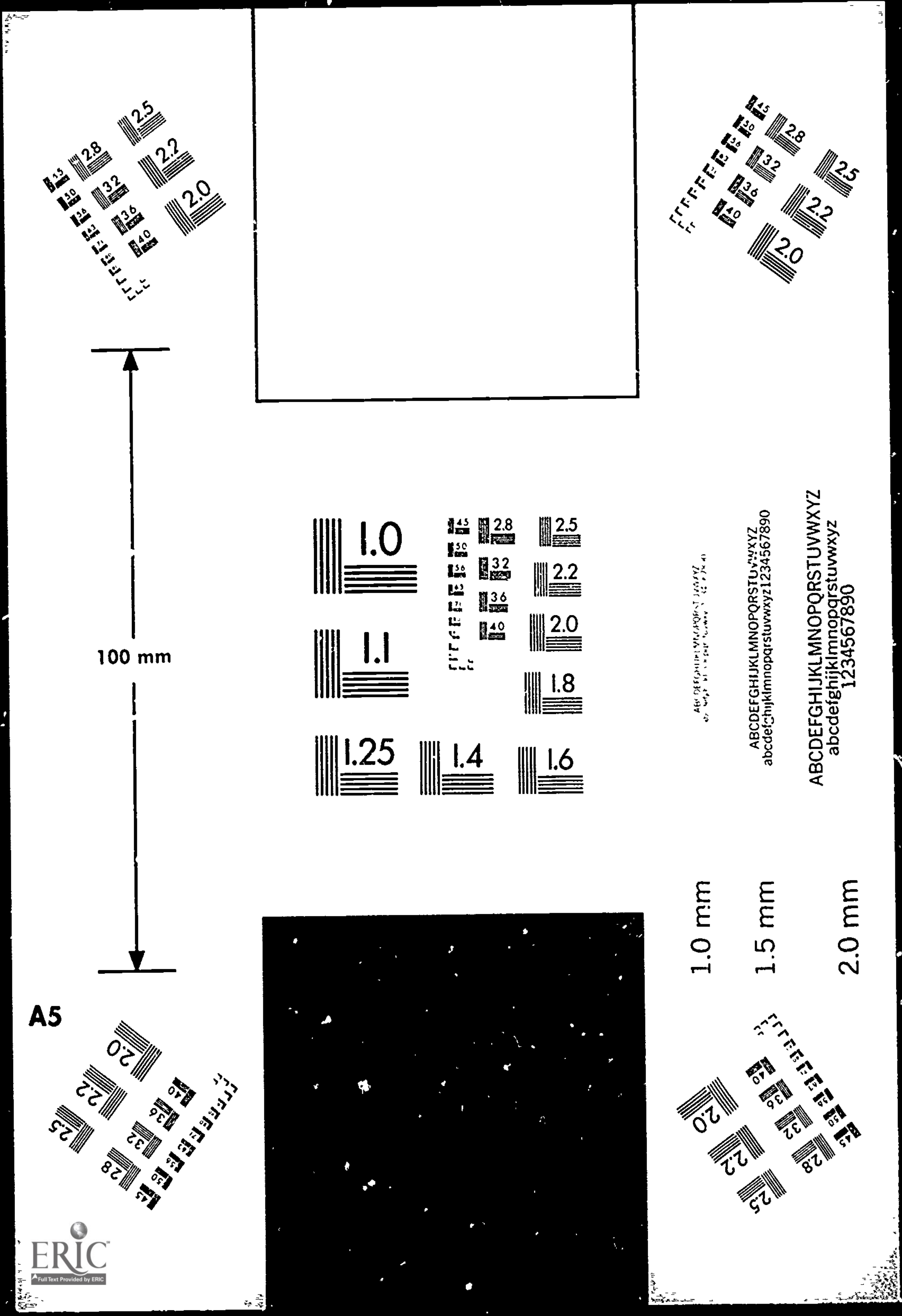
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ABSTRACT

Two pilot studies probed effectiveness of linguistically controlled, highly visual computer-assisted instruction (CAI) for English grammar instruction with hearing-impaired high school students (N=29 in the first study and N=71 in the second). Results from the first study suggested that state-of-the-art CAI designed specifically for use with this population improved students' ability to use articles with count nouns. The second study focused on use of icons to teach English syntax by symbolizing the essence of either a negative or an interrogative syntactical structure and asking students to rank icons implying "negation" or "interrogation." Those exposed to American Sign Language (ASL) selected icons reflecting facial expressions of a native ASL speaker, while those who communicated orally selected universal symbols found in English texts. (PB)

The Effectiveness of CAI Designed for the Hearing-Impaired

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Abstract

Two pilot studies were designed to determine the effectiveness of linguistically controlled, highly visual computer-assisted instruction (CAI) for hearing-impaired high school students. Study 1, *Using Articles*, evaluated a CAI intervention developed in IBM Logo. Our data suggested that state-of-the-art CAI, designed specifically for this population, improved the students' ability to use articles with count nouns. This study also attempted to discover whether or not there were differences in the effectiveness of this CAI approach for three specific populations: (1) students whose primary mode of communication was American Sign Language (ASL), (2)students who signed exact English (SEE II),and (3) students who communicated orally.

Study 2, *Choosing Advanced Visual Markers (AVMs)*, was the first investigation in a series of instructional interventions to determine the efficacy of using icons (AVMs) in CAI to teach English syntax to hearing-impaired high school students. Created using HyperCard on the Macintosh, the AVMs were designed to communicate the essence of a syntactical structure to be taught, e.g. a negative or interrogative pattern. *Choosing AVMs* evaluated the responses of four high school populations to eight different icon designs. In an interactive program the students were asked to rank the alternative AVMs that connoted "negation" or "interrogation." As in *Using Articles*, this study used three hearing-impaired populations to determine whether or not there were differences in the ranking of the icons by students with different, primary modes of communication. Preliminary findings suggested that students chose AVMs which were closely related to their language background. Those exposed to ASL selected AVMs which reflected the facial expression of a native ASL signer, while those who communicated orally selected the universal symbols found in English texts.

Introduction

The formidable difficulties that the deaf experience in learning English are reflected in the large numbers of functionally illiterate deaf adults. Instructional methods to date have not effectively developed the ability of the deaf to read and write English sufficiently. On the average deaf adults reach only a fourth grade reading level, and only 10% of the best 18 year-old deaf students read at or above the eighth grade level. Now, however, as an outgrowth of the seminal studies by Noam Chomsky in the late 1960's, the revolution in linguistic thinking has extended to studies of language and commmunication of the deaf. The pioneering work of William Stokoe (1960, 1975), followed by Bellugi (1972, Klima and Bellugi,1979), Newport (1977), Siple (1978), and Lane and Grojean (1980), firmly established American Sign language (ASL) as a "natural" language. Where English is a natural aural-oral language, ASL is a visual-gestural language which evolved to meet the specific communication needs of the deaf. Building upon ASL conceptualizations, the deaf may be able to acquire the linguistic structures with which they experience difficulty in English but which they acquire with facility in ASL.

In addition, the availability of new computer technology, which can be used for instruction, may remove many of the limitations with which educators and researchers have struggled. While hearing children enter school with a fairly complete knowledge of the syntax and lexicon of the English language, hearing-impaired students must simultaneously learn the language, and learn how to read and write that language. Without ever having heard English, students are expected to replicate the lexicon and syntax. Microcomputer-based language programs, however, may offer a way to capitalize on the prior language-related, visual knowledge that the hearing-impaired acquire in learning sign. Where English uses time and sequence, the computer courseware designer can use the ASL dimensions of position and motion in space to enhance language learning. Even though ASL functions in a visual-motor modality and English operates in an auditory-vocal modality, educational software may offer hearing-impaired students more rewarding opportunites for interactive, language experience than they usually experience. Maximizing the ASL aspects of visualization and simultaneity of expression, computer-assisted English language programs can use color, graphics, and windows to highlight and emphasize instructional points and informational feedback. Through CAI designed specifically for the hearing-impaired, a student may be motivated to interact with a rich language environment in which the syntax, vocabulary, and figurative language are linguistically controlled and incrementally graduated in terms of difficulty for hearing-impaired learners; language acquisition and usage can proceed at the learner's own

pace. This paper reports the results of two related studies which were designed to ascertain the effectiveness of CAI created specifically for hearing-impaired students.

Study 1: *Using Articles*

Programmed in IBM Logo to run on an IBM-PC with 256K, *Using Articles* was a preliminary investigation of the potential of CAI for effective instruction of English syntax with hearing-impaired students. The computer program was field-tested to answer two basic questions: First, can state-of-the-art educational software improve the ability of hearing-impaired learners to use articles with count nouns? Second, will there be differences in the effectiveness of this CAI approach for the three different hearing-impaired populations?

Sample

Three hearing-impaired high school populations comprised the study sample for *Using Articles:*

1. Ten "Oral-only" students, ages 14 to 18, were in a day program for the communicatively handicapped Oral-only indicates that the students' first language is English and that they communicate in an aural-oral mode.

2. Ten "Total Communication" students, ages 14 to 19, used SEE II and speech in a day program. SEE II, Signing Exact English, is a type of Manually-Coded English.

3. Nine "Total Communication" students, ages 14 to 16, were enrolled in a residential program, which used ASL or PSE (Pidgin-Signed-English) as their language of choice for personal communication.

Methodology

The program, *Using Articles*, was limited to three lessons which could be completed by an average subject in approximately one hour. The lessons consisted of exercises and paragraphs which focused on:

1. Choosing the article a or an

2. Using a, an, and the null article (ø) with singular and plural count nouns; for example, "balls" are "countable" while "air" is not. The null article indicates the lack of an article preceding plural count nouns; for example, he eats an apple every day, but he never eats ø pears.

3. Using a, an, the, and the null article (ø) in first and second mention. The first time a noun is mentioned, an indefinite article is used, but the second mention requires a definite article; for example, I found a key. Is it the key to your car?

At each of the three test sites, the goals of the program were explained and the students' support was elicited. After pencil-and-paper pre-tests were administered to each group, students proceeded through *Using Articles* individually; the learner controlled the pace. Within 24 hours of using the program, a post-test was administered. The format, level, and administration of the pre- and post-tests were comparable. The syntactical structures of the sentences in the pre- and post-tests were identical, but the nouns and verbs were different.

Results

Figure 1 reports the pre- and post-test scores of each group. Repeated Measures Analysis of Variance (ANOVA) showed that the three groups demonstrated improvement in all three topics. All pre- post-test differences were significant ($p < .05$).

1. A and An — Although significant, the slight improvement between 0 and 1 errors indicates a likely ceiling effect. The three groups seem not to have needed instruction on this topic.

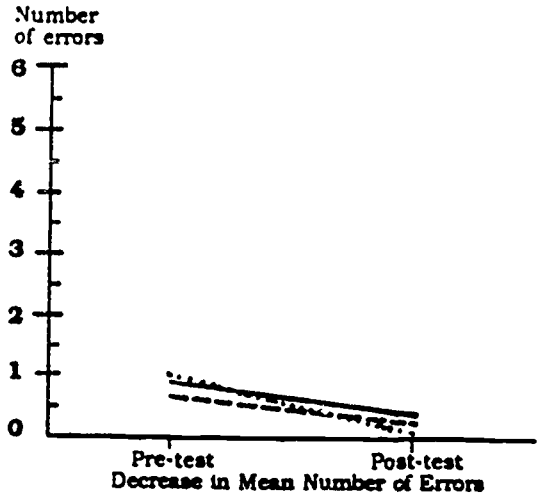
2. Singular and Plural — As in the case of "A and An," the Oral-only group seems not to have needed this lesson. As demonstrated by the number of mistakes on the pre-test, the SEE II and ASL groups needed and benefited from this lesson. Eight of the nine ASL students, and the ten SEE II students demonstrated improvement. Considering the brevity of the exposure — only one hour of intervention — it is surprising to see such a significant degree of improvement within these two samples.

3. First and Second Mention — The number of errors in the pre-test indicates that all three groups needed and benefited from instruction on this topic. Usually, hearing-impaired students with the most language make the most progress; however, in this difficult lesson the rate of improvement appears equally high for all three groups. The ASL and SEE II groups improved at a rate equal to their performance in the "Singular and Plural" lesson. However, the graph displaying this result masks substantial variance in the individual performances: more than half the students displayed strong and steady progress, one quarter (mostly from the Oral-only group) did not seem to need the instruction, and the other quarter did not benefit from the instruction. The mixed results from this most difficult lesson, "First and Second Mention," may be attributed in part to a need for more practice. Because there was a fixed amount of practice (one hour) across all three topics, one can speculate that additional practice in the more difficult areas would lead to an increase in learning.

Lesson 1: A and N

Group	n	Pre-test		Post-test	
		mean	s.d.	mean	s.d.
ASL-speech	9	0.9	1.27	0.4	0.73
SEE II-speech	10	0.6	0.84	0.2	0.42
Oral-only	10	1	1.56	0.1	0.32

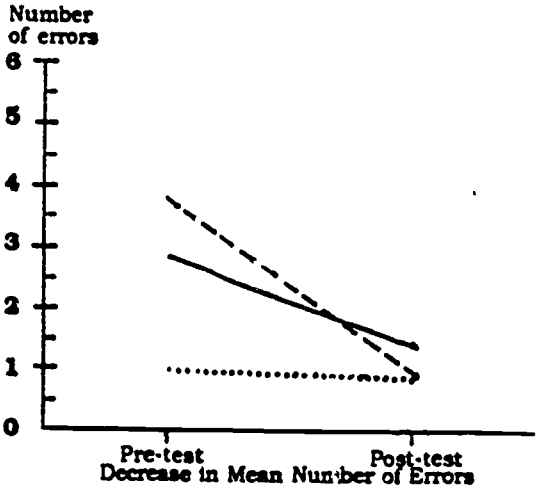
Mean Scores on Pre and Post-tests



Lesson 2: Singular and Plural

Group	n	Pre-test		Post-test	
		mean	s.d.	mean	s.d.
ASL-speech	9	2.8	1.72	0.9	0.78
SEE II-speech	10	3.7	1.83	1.3	1.34
Oral-only	10	0.9	1.29	0.8	1.32

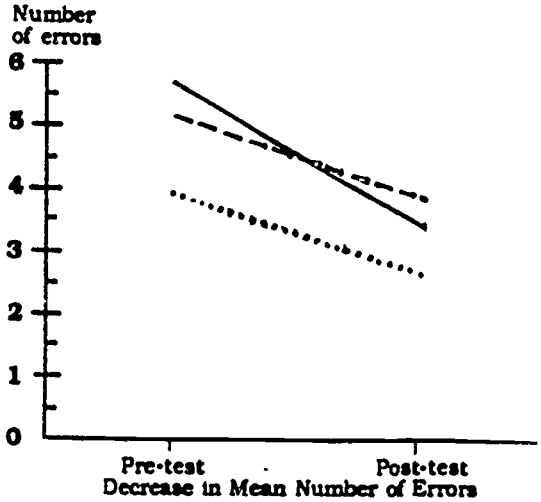
Mean Scores on Pre and Post-tests



Lesson 3: First and Second Mention

Group	n	Pre-test		Post-test	
		mean	s.d.	mean	s.d.
ASL-speech	9	5.6	1.51	3.4	2.01
SEE II-speech	10	5.1	2.08	3.8	1.87
Oral-only	10	3.9	3.04	2.6	2.01

Mean Scores on Pre and Post-tests



Key
- ASL-speech (Residential)
- SEE II-speech (Day Class)
- Oral-only (Day Class)

Figure 1. Mean Scores on Pre and Post-tests and Decrease in Mean Number of Errors for Three CAI Lessons

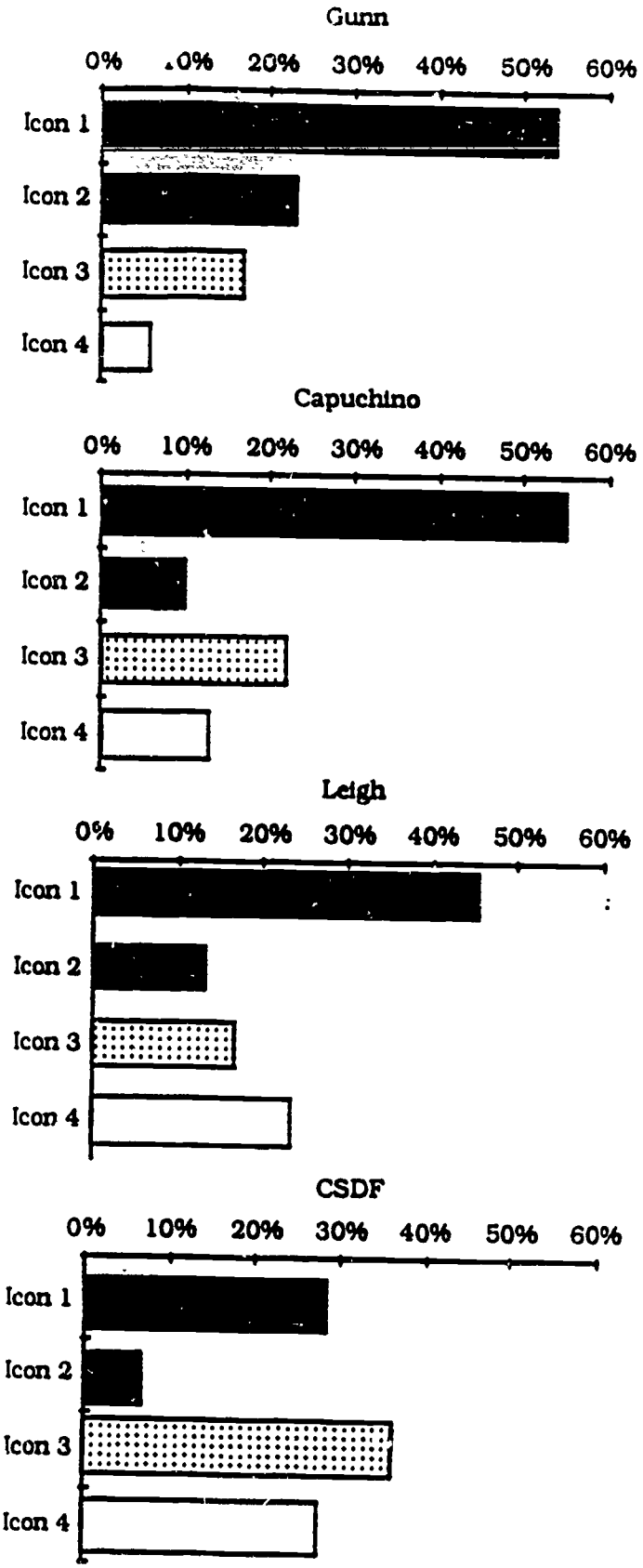
Considering the usual slow rate of improvement of syntactic structures among the hearing-impaired (Quigley, 1978), the encouraging findings from this carefully designed CAI intervention of short duration motivated us to study other aspects of ASL which could be transferred to an advanced computer technology. Our investigation led us to HyperCard on the Macintosh, which combines the ease of use associated with a graphic interface with the power of an object-oriented programming language. Critical components of our instructional approach, graphics and animation, are handled with facility and speed in HyperCard; presentation of the instructional design is delievered with appropriate speed on the Macintosh.

Study 2: *Choosing AVMs*

Programmed in HyperCard to run on a Macintosh, *Choosing AVMs* (Advanced Visual Markers) was the first investigation in a series of instructional interventions to determine the efficacy of using icons (AVMs) to teach English syntax to hearing-impaired students. (See the Icon Key in Figures 2 and 3.) In English the grammatical element that distinguishes a declarative sentence from an interrogative or negative one is syntax, i.e. word order; however, in ASL the grammatical signals that indicate sentence type are the signer's facial, eye and head behaviors. These highly visual, non-manual behaviors are produced concurrently with all the ASL signs for the concepts and words in the sentence (Baker, 1980).

To capitalize on ASL's visualization and simultaneity of expression in teaching English, we created AVMs (icons).to provide learners with a visual clue, or bridge. The AVMs were designed to denote the English language requirement for a transformation, a change in word order, when writing a negative sentence or question in English.

The first major step in developing instructional materials built around AVMs was to decide upon the optimal style of icon. We designed eight AVMs (icons): four for negation and four for interrogation. The AVMs ranged from abstract symbols to line drawings to the digitized photographs of a native ASL signer's facial expression when asking a yes-no question or expressing negation. Figures 2 and 3 display the negative and interrogative AVMs that were used in this pilot study.



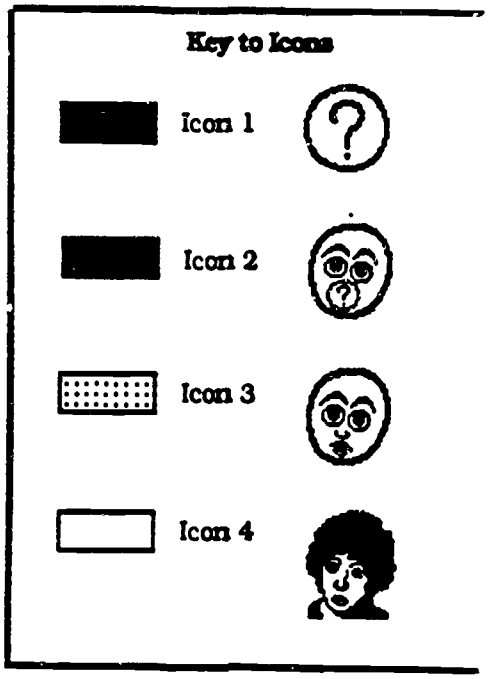


Figure 2. Percentage Ranking of Interrogative Icons by School Site

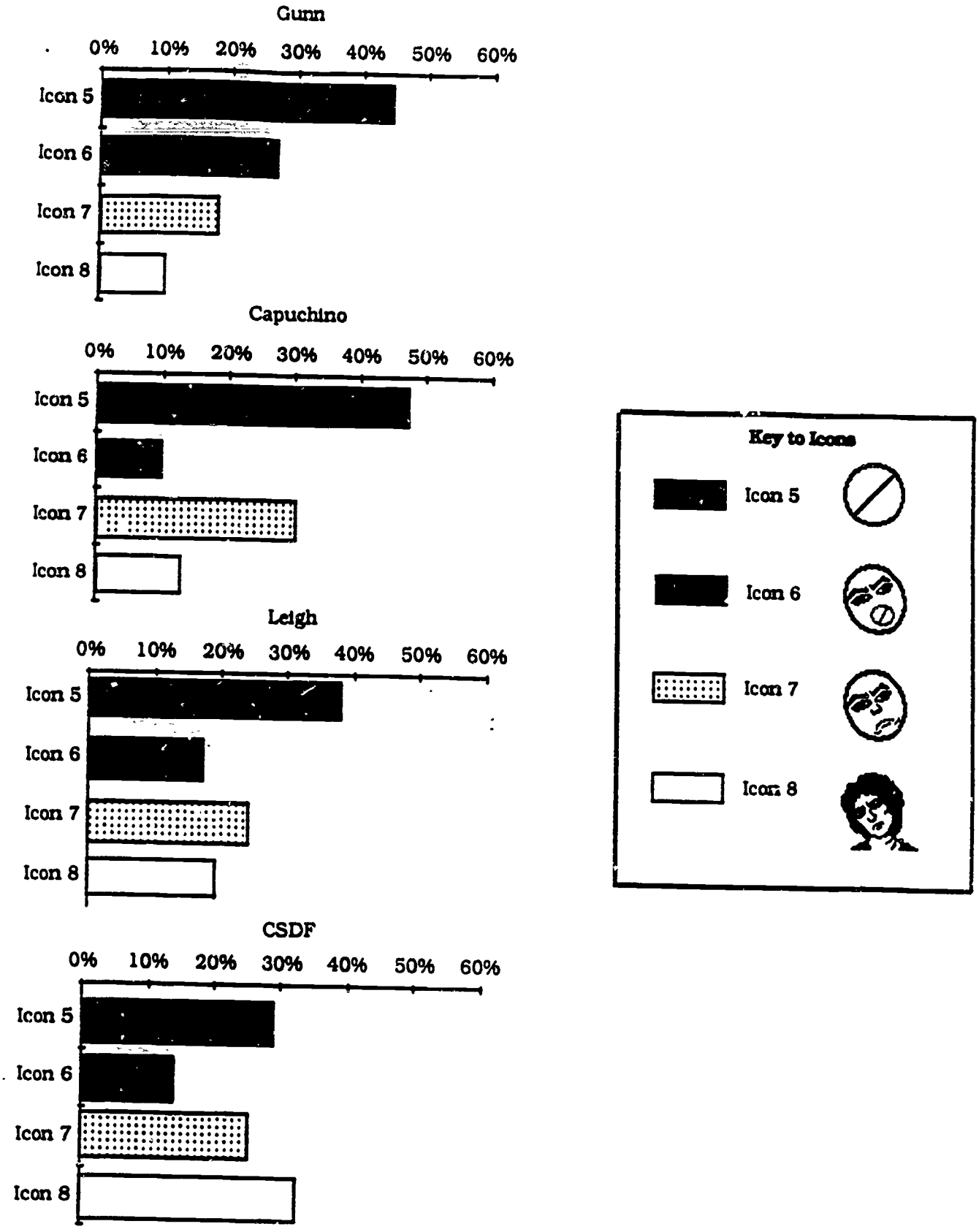


Figure 3. Percentage Ranking of Negative Icons by School Site

Choosing AVMs was designed to evaluate the responses of four high school populations to eight different AVM designs. In an interactive program the students were asked to rank the alternative AVMs that connoted "negation" or "interrogation." The study sought to determine the answers to two basic questions. First, would one AVM emerge as the dominant choice across all student populations? Second, would students choose AVMs which were closely related to their language background? For example, would students with exposure to ASL tend to choose Icons 4 and 3 for interrogation and 8 and 7 for negation because those AVMs were derived from the digitized image of a native ASL signer's facial expressions? In contrast, would the more aural-oral, mainstreamed students select the universal, textbook symbols in Icons 1 and 2 for interrogation, and Icons 5 and 6 for negation?

Sample

The sample for *Choosing AVMs* was drawn from four secondary school, hearing-impaired populations to determine whether or not there were differences in the ranking of the icons by students with different, primary modes of communication:

1. Twelve "Oral-only" students, ages 14 to 18, were in a day program for the communicatively handicapped at Gunn High.

2. Twenty-five "Total Communication" students, ages 14 to 19, used SEE II and PSE with speech in a day program at Leigh High.

3. Thirteen "Total Communication" students, ages 14 to 19, used SEE II, PSE, some ASL, and speech in a day program at Capuchino High.

4. Twenty-one "Total Communication" students, ages 14 to 19, used PSE and ASL with some speech in a residential program at the California School for the Deaf in Fremont (CSDF).

Methodology

To collect data about the AVMs (icons), we developed *Choosing AVMs* an interactive program in which 71 hearing-impaired students in four school settings assisted in designing their own instructional material by indicating their preferences for the AVMs currently under consideration. At each of the four test sites, the goals of the program were explained and the students' support was elicited. Each student proceeded through *Choosing AVMs* individually; the student controlled the pace. Following several interactive screens that explained the Macintosh interface, *Choosing AVMs* displayed eight sentences with corresponding pictures. Each sentence-

picture combination was displayed with each of the four appropriate AVMs, for negation or interrogation. The presentation order of the AVMs was randomized but did not include the possibility of the AVMs being presented as a continuum from abstract to concrete or vice-versa. After each sentence-picture-AVM display, the students were asked to rank the four AVMs according to the following criterion: which AVM best captured the essence of negation — or interrogation — for that sentence-picture? Data were collected on the presentation order and the ranked responses.

Results

Figures 2 and 3 show the students' percentage rankings of their choices of interrogative and negative AVMs respectively. Let us first describe the students' first choices by school, and then turn to differences across all choices by school.

The solid black bars on the histograms in Figure 2 show a consistent preference for Icon 1 — the most abstract, interrogative AVM — for all schools except CSDF. A plausible explanation for the difference in preference between students at CSDF and the other three sites could be that the students at CSDF have been exposed to and used sign language as a primary mode of communication. Because facial expressions tend to be incorporated as key syntactical elements in sign language, the AVMs derived from ASL facial expressions would be more familiar to these learners.

In contrast, because students at the other three sites have been mainstreamed for a number of years, their language experiences tend to resemble those of hearing populations. As a result, their AVM preferences would be more closely related to the abstract punctuation symbols more familiar to learners sharing conventional, English language instruction.

Looking beyond first preferences, of particular note is the pattern of responses displayed in Figure 2. While Gunn students showed a progressively decreasing interest in icons along the abstract to concrete continuum, with only 23% choosing interrogative Icons 3 and 4, the CSDF students displayed a strong interest in the more concrete ASL-like respresentations; 65% selected Icons 3 and 4. Again, this preference is likely a reflection of the CSDF students' visual mode of learning and exposure to ASL. As a result, their preferences for Icons 3 and 4, the line drawing and the digitized photographic image of a native ASL signer using the facial expression for a yes-no question, are quite understandable. In contrast, the Gunn students' primary mode of communication is aural-oral English, with little or no exposure to ASL.

The responses displayed in Figure 3 show a pattern similar to Figure 2. Only 29% of the Gunn students expressed an interest in the ASL AVMs, Icons 7 and 8. In contrast, 58% of the CSDF students selected Icons 7 and 8. To deaf students, like those at CSDF who heavily rely on visualization, facial, eye and head behavior play a dominant role in their communication. Yet over all schools, the pattern of preferred icons was not as consistent for negative sentences as it was for interrogative. Capuchino students, like those at CSD, showed a preference for an AVM other than the most abstract. Further analysis of this data may reveal more about the underlying causes for these response patterns.

Educational Importance of Studies 1 and 2

The data from these preliminary studies are encouraging. The results of *Using Articles* suggest that state-of-the-art, computer-assisted language instruction may be of benefit for all three populations studied. Although secondary school hearing-impaired students may not need direct instruction or intensive review of "A and An," most are likely to require work in the areas of "Singular and Plural" and "First and Second Mention." Where needs are demonstrated, innovative CAI, even of a relatively short duration, has powerful effects. The fact that pre-post gains were similar for all three groups suggests that such programs may enable all hearing-impaired students to improve their English regardless of the degree of their hearing loss.

Students participating in *Choosing AVMs* responded positively to the opportunity to participate in the design of their own instructional material. Although the AVM preferences among the four school sites were significantly different, the study revealed interesting differences within each school population. Rather than assign a dominant AVM to all students at a given school site, the program can be designed to allow individual students to select whichever AVM best reflects their individual preferences. In fact, students could select different AVMs as they proceeded through the instructional series.

Even though these studies indicate the positive effect of linguistically controlled, highly visual CAI for hearing-impaired students, the studies have a number of areas to investigate. The next step in our research will be the development of *Using AVMs*. In order to link the English syntactical structure to a visual ASL construct, we will pair the AVM with the English structure; computer animation will be used to maximize the transfer of relevant knowledge. Multiple opportunities for initiating interactive practice will be provided. As the learner becomes proficient, the AVM will fade, enabling the hearing-impaired learner to become familiar with typical

presentations of English syntax. If a student's performance begins to decline, the icon will reappear.

Using AVMs will incorporate a series of studies of two syntactical structures: negation and interrogation. Each study will be a contolled experiment involving the formation of treatment and conrol groups with random assignment of subjects to groups. The experiments will all be tests of the null hypothesis. We will determine whether we can reject the proposition that the use of AVMs has no effect on the amount of syntactical knowledge learned from a CAI presentation that cannot be accounted for by chance. In each study treatment and control subjects will receive almost identical treatments, the single difference being that the treatment subjects will have AVMs embedded in their CAI presentations.

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